

Optical Spectroscopy of the unusual galaxy J2310-43¹

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ABSTRACT

We present and discuss new spectroscopic observations of the unusual galaxy J2310-43. The observations cover a wide wavelength range, from 3700Å to 9800Å allowing the study of both the regions where $H\alpha$ and the Ca II “contrast” are expected. No evidence for $H\alpha$ in emission is found and we thus confirm the absence of emission lines in the spectrum of J2310-43, ruling out the possibility that it may host a Seyfert nucleus. The CaII break is clearly detected and the value of the contrast ($38\% \pm 4\%$) is intermediate between that of a typical elliptical galaxy ($\approx 50\%$) and that of a BL Lac object ($\leq 25\%$). This result imposes limits on the intensity of a possible non-stellar continuum and, in the light of the radio and X-ray loudness of the source, draws further attention to the problem of the recognition of a BL Lac object. Objects like J2310-43 may be more common than previously recognized, and begin to emerge in surveys of radio-emitting X-ray sources.

Subject headings: galaxies: active - galaxies: individual (J2310-43) - galaxies: nuclei - BL Lacertae objects

1. Introduction

In a recent paper, Tananbaum et al. (1997) have reported a detailed analysis of a ROSAT PSPC observation of J2310-43, a very peculiar and interesting galaxy firstly discovered as a luminous X-ray source ($\sim 10^{44}$ erg s⁻¹) in an *Einstein* IPC image (Tucker, Tananbaum & Remillard 1995). The IPC data showed that the X-ray source is spatially

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extended. This, combined with the fact that the galaxy is a cD in cluster (Tucker, Tananbaum & Remillard 1995) supported the hypothesis that the X-ray emission is due to the cluster, rather than to the activity of the galaxy itself. However, on the basis of the X-ray spatial and spectral analysis of the PSPC data, Tananbaum et al. (1997) suggested that only 20% of the total X-ray emission comes from the cluster, while the bulk is associated with a nuclear activity of the galaxy. Optical spectroscopy of the galaxy (Tucker, Tananbaum & Remillard 1995), however, did not reveal the emission lines or the excess blue continuum expected if J2310-43 contains an active nucleus.

Another interesting possibility considered by Tananbaum et al. (1997), is that J2310-43 is related to the BL Lac phenomenon. The lack of emission lines in the optical spectrum would apparently support this view. Furthermore, the broad band energy distribution of J2310-43, i.e. the position of the object in the α_{ro}/α_{ox} plane (Tananbaum et al. 1997), falls at the edge of the region occupied by BL Lac objects (Stocke et al. 1991). On the other hand, the same authors show that the (B-V) color observed in J2310-43 is consistent with that of a normal elliptical galaxy and it is rather different from that of a typical BL Lac object. The resulting picture is rather intriguing with contradicting or inconclusive evidences as for the presence of “nuclear activity”. Indeed Tananbaum et al. (1997) leave open the question whether J2310-43 belongs to the tail of the BL Lac population or to a different class of objects and point out similarities with the optically dull galaxies with strong nuclear X-ray emission discovered by Elvis et al. (1981).

The spectroscopic data on J2310-43, however, were limited to the 4700Å– 6700Å interval thus excluding two regions critical for the understanding of the nature of the source: that of the Ca II break (expected at $\sim 4355\text{\AA}$) and of the $H\alpha$ line (expected at $\sim 7145\text{\AA}$). In fact AGNs showing no $H\beta$ and [OIII] lines but exhibiting a broad $H\alpha$ line are known to exist (Stocke et al. 1991; see also Halpern, Eracleous & Forster 1997). For these reasons the possibility that J2310-43 is hosting a reddened Seyfert nucleus or a BL Lac object could not be completely ruled out.

With the aim of further studying J2310-43 and understanding its real nature we have therefore secured two optical spectra covering the wavelength range 3700Å – 9800Å.

2. Observation and analysis

Spectroscopy of J2310-43 was carried out with the ESO 3.6m telescope on 1996 December 10. Observations were made with EFOSC1 in longslit mode, using a 1.5 arcsec wide slit and two different grisms, b300 and r300, with wavelength coverage from 3700Å

to 6800Å and from 6200Å to 9800Å, respectively. The dispersions achieved with the two grisms, scaled to the Tek512 CCD detector, were 6.3 Å/pixel (b300) and 7.5 Å/pixel (r300). The exposure time was of 600 sec with the grism b300 and of 300 sec with the r300.

The data were reduced using the IRAF-LONGSLIT package³. The wavelength solution was obtained using a He-Ar reference spectrum while the correction for the instrument response was based on the observation of a photometric standard (LTT 377). We did not make an absolute flux calibration, thus the flux density scale of the spectra is in arbitrary units.

The calibrated spectra are presented in Figure 1.

3. Discussion and conclusions

The spectra presented in Figure 1 cover a wavelength range considerably larger than that of the spectrum discussed in Tucker, Tananbaum & Remillard (1995). In particular, the region of the [OII], CaII break ($\approx 4355\text{\AA}$) and the region where H α is expected (7145Å) are fully covered. No emission lines appear in the spectrum, which shows only the typical absorption features of a “normal” early type galaxy. From the main absorption features seen (Ca II H&K, G band, H β , MgI 5175Å, Na I D) we have computed a redshift of $z = 0.0887 \pm 0.0002$, confirming the value found by Tananbaum et al. (1997).

The first result worth noting is the absence of H α in emission. The fact that no emission lines are present from [OII] to [NII] definitively put to rest the possibility that a Seyfert nucleus is hiding in J2310-43.

Secondly, we note that a pronounced Ca II contrast is detected. We have computed its amplitude following Dressler & Shectman (1987), i.e. by estimating the average fluxes (expressed in unit of frequency) between 3750Å-3950Å (f^-) and between 4050Å-4250Å (f^+) in the rest-frame of the source; the contrast is then defined by:

$$CaII = \frac{f^+ - f^-}{f^+} \quad (1)$$

We have found, using the central part of the spectrum to minimize the stellar contribution, a Ca II contrast of $38\% \pm 4.0\%$, which is below the mean value found for a “normal” elliptical galaxy ($\approx 50\%$, Dressler & Shectman 1987).

³IRAF is distributed by NOAO, which is operated by AURA, Inc., under contract to the NSF.

If one considers the “canonical” limit of 25% for the definition of a BL Lac object (Stocke et al. 1991) then J2310-43 cannot be considered a BL Lac. On the other end Marchã et al. (1996) have proposed that objects with a Ca II contrast below 40% are likely to have an extra source of continuum, besides stellar, and consequently they have to be considered as possible low-luminosity BL Lac candidates.

The observed contrast can be used to set limits on the presence of such a non-stellar continuum, at least in the wavelength range $3700\text{\AA} - 4300\text{\AA}$ (object rest frame). To this end, we have considered the spectrum of a “normal” galaxy, showing a Ca II contrast of about 60%. Then, we have “added” a non-stellar continuum to the spectrum, in the form of a power-law ($f_\nu \propto \nu^{-\alpha}$) with a spectral index ranging from 0 to 2, and we have computed the Ca II contrast as a function of the fraction of non-stellar over stellar continuum. Our results show that the Ca II contrast is about 40% if the non-stellar contribution is approximately equal to the stellar continuum, (integrated between 3750\AA and 4250\AA). Values of the contrast of $\leq 25\%$ (the limit used to define a BL Lac object) are obtained when the non-stellar contribution is about 3 times or more higher than the stellar continuum. Thus, in J2310-43, which has a Ca II “contrast” of $\sim 38\%$, the non-thermal component can still be present but at an intensity level comparable or lower than the fraction of the stellar continuum falling in the extraction region within the slit aperture. We have also extracted the spectrum of J2310-43 considering only the outer region of the galaxy, thus minimizing the contribution of the nucleus, and we have found that the Ca II “contrast” increases to $47\% \pm 5\%$. We consider this as a further evidence that J2310-43 harbors in its nucleus a weak source of non-thermal continuum that can be detected only if the stellar contribution falling in the aperture is kept at a minimum. These results are consistent with the observed color of J2310-43 (determined for the whole galaxy) that indicates a negligible non-stellar contribution in the optical band, as discussed by Tananbaum et al. (1997).

In conclusion, the spectroscopic observations of the galaxy J2310-43 presented here support the interpretation that this object represents the faint tail of the BL Lac population, in which the extra source of continuum is present but does not contribute significantly to the optical spectrum.

Further observations (polarization, radio spectral index, high resolution X-ray spectroscopy, etc.) are obviously needed to characterize the presence of such non-thermal continuum emission in J2310-43.

It is worth noting that a similar object (E0336-248) has been recently discovered by Halpern et al. (1997). Also in this case, the computed Ca II “contrast” (33%) does not meet the nominal criterion of $\leq 25\%$ for classification as a BL Lac object. Nevertheless, these authors have produced convincing evidence for the presence of a non-stellar continuum in

the spectrum of E0336-248 and, consequently, for its classification as a weak BL Lac object. Clearly, a re-assessment of the Ca II “contrast” criterion for the definition of a BL Lac is needed.

Tananbaum et al. (1997) ask “how common are sources such as J2310-43?” We have reason to believe that they may be more common than currently recognized. We have recently initiated a survey of Radio Emitting X-ray sources (the REX Survey, Caccianiga et al. 1997a, 1997b) with the aim of selecting a new large sample of BL Lac objects and radio loud quasars. To enter the sample, a source has to be detected in a pointed ROSAT PSPC observation *and* in the VLA NVSS survey, above well defined flux limits and thresholds. During the optical identification program of the REX sources we have already found six objects that are similar to J2310-43. The properties of these objects will be presented and discussed in detail elsewhere; here we recall that, like J2310-43, they have X-ray luminosity in the range $10^{43} - 10^{45} \text{ erg s}^{-1}$ (0.5 - 2.0 keV) and radio luminosity in the range $3 \times 10^{30} - 3 \times 10^{31} \text{ erg s}^{-1} \text{ Hz}^{-1}$ (1.4 GHz). They are all radio loud ($\alpha_{ro} > 0.35$) and they all have a CaII “contrast” between 25% and 40% and no emission lines in their spectrum. They do not seem to lie preferably in a cluster environment. We note that these six objects have been found out of ~ 100 new spectroscopic identifications. It is unfortunate however that, given the very low identification rate so far obtained for the REX survey, we cannot, at present, make an estimate of the space density of these objects.

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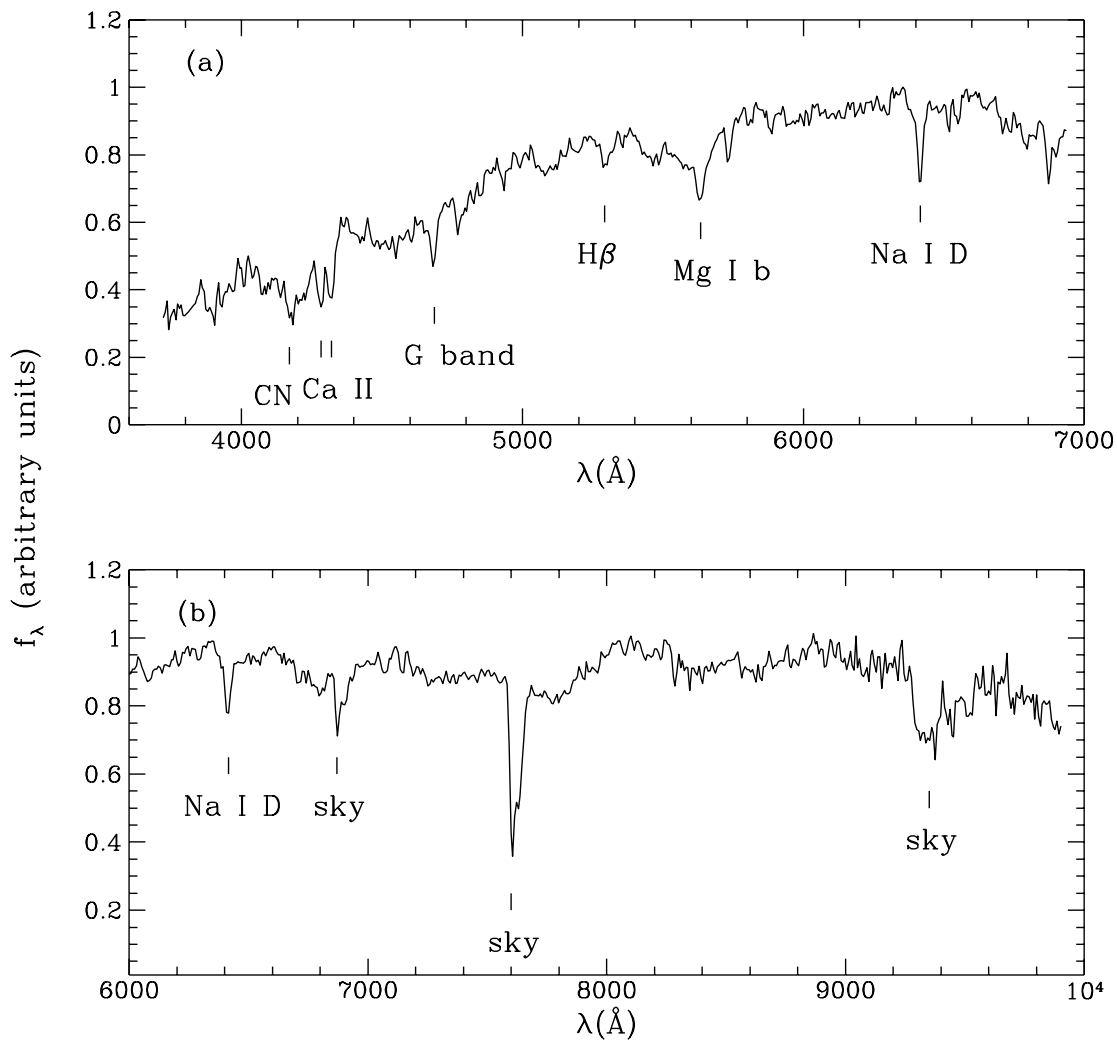


Fig. 1.— The optical spectrum of J2310-43 obtained with the ESO 3.6 m telescope+EFOSC1 with two different grisms: b300 (a) and r300 (b). The flux (f_λ) is in arbitrary units.